

6.1 South Georgia Strait

A. Assessment

1. Salmon Use

Chinook

This is part of the South Georgia Straits and San Juan Islands region, which includes two independent populations, both of which emanate from this sub-basin:

- North Fork Nooksack
- South Fork Nooksack

a) Juvenile

- Juvenile Chinook salmon of all four life history types of the Nooksack populations, and larger juveniles from throughout Puget Sound (particularly from the Skagit River), utilize this sub-basin for feeding and growth, refuge, physiological transition and as a migratory corridor (juvenile salmon functions).
- Juvenile Chinook salmon have been shown to utilize small (and large) freshwater streams for direct rearing. The Dakota Creek – Point Roberts area is part of the geomorphic structure of the Fraser River delta that contains estuarine rearing habitats supporting natal Chinook outmigrants. The area is also believed to provide significant rearing potential to juvenile Chinook emanating from rivers in other sub-basins. We hypothesize this non-natal support is especially important to the northern Puget Sound populations (i.e., see Table 3-1 for the list of northern Puget Sound populations).

b) Adult

- Adult Chinook salmon of the North Fork and South Fork Nooksack populations and from other Puget Sound populations utilize the South Georgia Strait (Kurt Fresh [NOAA-NWFSC], Bill Graeber [NOAA-TRT], pers. comm.). In addition to Dakota Creek mentioned above, Chinook salmon are documented as using the Lummi River (Figure E-1.1 in Appendix E).
- Adult salmon from far outside Puget Sound (e.g., Columbia River ESU's) are known to frequent this sub-basin (Kurt Fresh [NOAA-NWFSC], Bill Graeber [NOAA-TRT], pers. comm.).

Other Listed Species (not comprehensively reviewed or assessed for this sub-basin)

- Chum salmon: Populations of the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU do not emanate from this sub-basin. Non-natal use may occur, but it is not known for certain. This sub-basin is outside the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU
- Bull trout (anadromous): Occurs in one core area (Nooksack) in this sub-basin. The core area contains an estimated 10 local populations, fewer than 1000 adults (estimated) and an unknown population trend (numbers generally low) (USFWS 2004). The Nooksack core

area is critical for sustaining the distribution of the anadromous bull trout life history trait within Puget Sound.

2. Ecological and Landscape Conditions

Food Web, Ecological Conditions

In the Strait of Georgia, the peak abundance of zooplankton has shifted from the month of May (1960s and 1970s) to April (1990s), presumably due to higher temperatures (Ruggerone and Goetz, 2004). Pacific herring are one type of forage fish that prey heavily upon zooplankton (West, 1997), and herring and other small schooling fish are thought to be an important part of the diet of salmon (Bargman 2001) and bull trout (USFWS 2004). In this sub-basin, Cherry Point herring, once the largest stock in Washington with spawning grounds extending from north Bellingham Bay to the Canadian border, have declined 94% from historic levels (Bargman 2001). Suspected causes for decline are discussed below. Cherry Point herring are a spring spawning stock, different from the other herring stocks in Washington, which are winter spawning stocks (e.g., Semiahmoo Bay herring stock in this sub-basin) (Bargman 2001). Many early spawning stocks in Puget Sound have not declined as much as the Cherry Point stock (Ruggerone and Goetz, 2004).

The major 1982-1983 El Nino event is thought to have affected survival of Puget Sound Chinook since that time (Ruggerone and Goetz, 2004). In the Strait of Georgia, most pink salmon enter marine waters in April, before Chinook salmon, and during even-numbered years. Prior to the large El Nino event, Chinook experienced greater survival during even-years, but since the El Nino event of 1982-1983 survival has been reduced, and Ruggerone and Goetz (2004) have hypothesized this is due to increased competition with pink salmon for prey resources. As a result, juvenile Chinook salmon may be entering marine waters at a time of reduced prey availability (Ruggerone and Goetz, 2004). In addition, the substantial decline in spawning Cherry Point herring during the early 1980s coincides with the reduced survival of Chinook and an increase in pink salmon abundance (Ruggerone and Goetz, 2004).

Landscape Conditions

In general, shorelines within the South Georgia Strait sub-basin are open to large fetches from the southwest and are therefore susceptible to wave-dominated processes like strong nearshore drift. This part of the sound also has reduced tidal amplitude compared to points further south and so waves have the opportunity to rework sediments in a finer elevation band along the shoreline. While the waters of South Georgia Strait generally exchange well through tidal action with Pacific Ocean waters, there are several places where localized oceanographic conditions create recirculating gyres which tend to increase water residence times making those waters susceptible to eutrophication and other water quality problems. (Refer to Appendix E, Figures E-1.1 through E-1.5.)

Overall area (shown in Figure 2-3 in Section 2)

- Total area (deep-water plus nearshore) is 279,999 acres (437.5 square miles).
- Deep-water portion (marine waters landscape class) comprises 216,703 acres (338.6 square miles), or 77% of the total sub-basin area.

Nearshore area

- Nearshore portion comprises 63,295 acres (98.9 square miles), or 23% of the total sub-basin area. As part of the nearshore, the Nooksack estuary (landscape class) is a natal estuary for the independent Chinook populations listed above, comprising 43.79 square miles (44%) of the total nearshore area within this sub-basin (Figure E-1.1, Appendix E).
- Nearshore area within this sub-basin is 15% of the nearshore area of the entire Puget Sound basin.
- Contains 218 miles of shoreline (beaches landscape class).
- The “key” bays (landscape class) identified in this sub-basin are Semiahmoo Bay, Birch Bay, Lummi Bay, Bellingham Bay, and Chuckanut Bay (Figure E-1.1, Appendix E).
- Thirty-one linear miles (14%) of the shoreline is designated as marine riparian (defined as the estimated area of length overhanging the intertidal zone).
- In this sub-basin, 46% of the shoreline (101 linear miles) has eelgrass (*Zostera marina* and *Z. japonica*); may be patchy or continuous.
- In this sub-basin, 17% of the shoreline (38 linear miles) has floating kelp; may be patchy or continuous. Also in this sub-basin, 35% of the shoreline (77 linear miles) has non-floating kelp; may be patchy or continuous.

Pocket Estuary Analysis

Our visual analysis of pocket estuaries in this sub-basin revealed 14 pocket estuaries: two in Drayton Harbor, three in Birch Bay, seven within Bellingham Bay, one on Lummi Island and one on Point Roberts (Figure E-1.4, Appendix E). Among the results were:

- Freshwater sources were observed in all but two of the pocket estuaries,
- Based on the assumptions listed in Appendix B, all three of the Chinook functions (feeding, osmoregulation and refuge) were estimated to occur in 11 of the 14 pocket estuaries.
- Composite “scores” were generated for each pocket estuary based on likely Chinook functions and stressors observed during analyses. None of the pocket estuaries were estimated to be *properly functioning*. Four of the 14 were estimated to be *not properly functioning*. The remaining pocket estuaries were recorded as *at risk* (Figure E-1.2, Appendix E).

Drift Cell Analysis

A drift cell characterization for this sub-basin is presented in Appendix E, Figure E-1.5 and subsequent text. Broad intertidal and subtidal shelves that provide shallow, vegetated patches and corridors along the shoreline are a depositional feature of soft sediments generally at the depositional portions of drift cells or at the intersection of longshore drift and deltaic processes. Descriptions of littoral drift, feeder sources, deltaic processes, deposition, and recommendations for

protection and restoration of longshore drift functions are presented in Appendix E. Recommendations for protection and restoration are highlighted in Tables 6-2 and 6-3.

Threats/Stressors

Loss and/or simplification of delta and delta wetlands

Comparison of historical wetland area and wetland area reported in Bortleson et al. (1980) revealed that for the Nooksack delta, the estimated area of intertidal wetlands increased from 2.59 to 3.28 square miles (increased by 0.69). In this same delta, the estimated area of subaerial wetlands increased from 1.73 to 1.77 square miles (increased by 0.04). However, the lack of dendritic channel structure in the newly created delta may result in a loss of accessible habitat for delta fry life history type Chinook. For the Lummi delta, the estimate area of intertidal wetlands decreased from 5.40 to 5.01 square miles (decreased by 0.39). In this same delta, the estimated area of subaerial wetlands decreased from 2.24 to 0.12 square miles (decreased by 2.12). Historically, the Nooksack mainstem contained floodplain wetlands and extensive estuarine marshes, but now a less complex channel pattern exists for the upper Nooksack mainstem, due in part to levees and isolating meanders (Collins et al, 2003).

Alteration of flows through major rivers

A City of Bellingham diversion dam is located on the Middle Fork Nooksack River, but is without a reservoir and does not interrupt sediment or large woody debris movement (USFWS 2004). A formerly abandoned, but recently employed hydropower facility is located on the North Fork Nooksack River (USFWS 2004). Additional diversions of the Nooksack occur for irrigated agriculture, industrial uses at the Cherry Point refinery complex and the cities of Lynden and Ferndale. In all these cases flow is reduced from within the Nooksack channel.

Modification of shorelines by armoring, overwater structures and loss of riparian vegetation/LWD

The projected population growth in Whatcom County between 2000-2025 is 48% (79, 822 people) (PSAT 2005). Shoreline armoring occurs along 47.1 miles (21.3%) of the shoreline (Figure E-1.3, Appendix E). Over 39 miles of shoreline are classified as 100% armored. Nearly 152 miles are classified as 0% armored. The total number of overwater structures in this sub-basin is 2,843, consisting of ramps (118), piers and docks (257), small slips (2,401) and large slips (67). These structures are observed in greater concentrations in Drayton Harbor, Birch Bay, Sandy Point, and Bellingham Bay. Within 300 feet of shore, railroads occur along 8.5 miles of shoreline, from Chuckanut north to Bellingham and sections of Bellingham Bay, and again at the northeast section of Drayton Harbor.

Contamination of nearshore and marine resources

Industrial shorelines are located in several locations of this sub-basin, including Bellingham Bay and the Cherry Point region. The Cherry Point area experiences substantial shipping and petroleum movement, which occurs in the region of herring spawning grounds (Bargman 2001). A study conducted by the University of Washington, in response to potential contamination of herring

spawning grounds, revealed that at Cherry Point the herring experienced a) low hatching rates from eggs, b) smaller newly hatched larvae, and c) high rate of abnormal development (Bargman 2001). Alternative hypotheses are being investigated regarding these abnormalities at this time.

Bellingham Bay is one of three locations sampled ('historic' data set from 1989 through 1996 compared to 2000) where PAH levels increased (PSAT 2002a).

Analysis of sediment samples in randomized site locations between 1997 and 1999 showed Bellingham Bay is one of several urban locations with extensive sediment contamination: 10% of the Bellingham Bay area exceeds state sediment quality standards and 2.1% exceeds cleanup screening levels (PSAT 2002a). Impaired invertebrate communities were identified in Bellingham Bay (PSAT 2002a).

Five sewage outfalls (Figure E-1.3, Appendix E) and an unknown number of stormwater discharges are also observed in this sub-basin.

Water quality impairments in this region are indicated in Figure E-1.3 (Appendix E).

Alteration of biological populations and communities

An unknown number of hatcheries, net pen facilities, and shellfish operations are found in this sub-basin. Specific hatchery reform recommendations formulated for this region by the Hatchery Scientific Review Group are presented at:

http://www.lltk.org/pdf/HSRG_Recommendations_March_2003.pdf

Transformation of land cover and hydrologic function of small marine discharges via urbanization

Figure E-1.2, Appendix E, presents land cover information for the lands surrounding this sub-basin. Figure E-1.4, Appendix E, lists pocket estuaries and notes stressors observed from review of oblique aerial photos. We determined that Whatcom Creek, Squaticum Creek, Birch Bay and Point Roberts pocket estuaries are not properly functioning due to urbanization impacts to juvenile salmon functions (Figure E-1.4, Appendix E). Given current development pressure, we determined that Chuckanut Creek, Padden Creek, Terrell Creek, California Creek and Dakota Creek pocket estuaries are at risk of losing functions due to urbanization.

Transformation of habitat types and features via colonization by invasive plants

Spartina spp. is not recorded in this sub-basin. However, 41% of the shoreline (90 miles) contains *Sargassum muticum*.

B. Evaluation

In this section we list goals and evaluate the level of realized function for natal and non-natal Chinook, summer chum, and bull trout. From this we then list each of the proposed protection and restoration actions for this sub-basin, and describe the benefits to natal Chinook, non-natal Chinook, and summer chum and bull trout (if any).

Goals for listed salmon and bull trout whose natal streams are in this sub-basin

- a) Provide early marine support for all four life history types (fry migrants, delta fry, parr migrants, yearlings) of Nooksack Chinook salmon populations: connectivity of habitats, prey resources
- b) Provide support for sub-adult and adult Chinook salmon populations who utilize habitats within this sub-basin as a migratory corridor and grazing area
- c) Maintain anadromous life form of bull trout by preserving forage fish species and marine foraging areas. Provide marine support for sub-adult and adult anadromous bull trout populations as foraging, migration, and overwintering habitat
- d) Provide for connectivity of habitats; also, adequate prey resources, marine foraging areas, and migratory corridors for juvenile, sub-adult and adult Chinook and bull trout
- e) Provide early marine support for independent spawning aggregations of Chinook occurring in this sub-basin.

Goal for listed salmon and bull trout whose natal streams are in other sub-basins

- a) Provide support for all neighboring Puget Sound populations, the Skagit River Chinook populations in particular, as well as Fraser River (Canada) populations and larger juveniles from other sub-basins.

Realized function for listed salmon and bull trout

Fry migrant Chinook – The condition of pocket estuaries within 5 and 10 miles of the Nooksack estuary (Figure E-1.2 in Appendix E) suggests that Chinook fry migrants may not be well supported unless conditions are improved through restoration. Fry migrants utilizing pocket estuaries and shorelines of Bellingham Bay may not be supported because of poor water quality, loss of large expanses of eelgrass, and loss and degradation of smaller estuaries and shallow water. Fry migrants may experience similar disruptions to their migratory corridors as delta fry. Any oil spills from the industrial center of Cherry Point and Bellingham Bay are a threat to this life history type.

Delta fry Chinook – During even-numbered years, juvenile Chinook salmon of this life history type may be entering marine waters at a time of reduced prey availability due to competition with pink salmon for resources (Ruggerone and Goetz, 2004). In addition, delta fry in Bellingham Bay are likely to have a higher level of exposure to toxic contaminants than other life history types. Delta fry that emerge as parr may encounter only minor disruptions in their migratory corridor if they travel northward toward pocket estuaries in Drayton Harbor and Birch Bay but potentially more frequent and intense interruptions if they migrate southward to Padilla and Samish Bays because of a higher degree of shoreline clearing, armoring and wastewater discharges in Bellingham Bay. However, the role of the extensive eelgrass bed within Padilla Bay may support migrating parr in a way that is currently not understood. The opportunity for delta fry to access intertidal areas of the Lummi delta are severely curtailed. Any oil spills from the industrial center of Cherry Point and Bellingham Bay are a threat to this life history type. Loss and degradation of small estuaries and shallow water areas has reduced the availability of prey and refuge as well as disrupted migration for this life history type.

Parr migrant Chinook – During even-numbered years, juvenile Chinook salmon of this life history type may be entering marine waters at a time of reduced prey availability due to competition with pink salmon for resources (Ruggerone and Goetz, 2004). Any oil spills from the industrial center of Cherry Point and Bellingham Bay are a threat to this life history type if present at the time of the spill. Loss and degradation of small estuaries and shallow water areas has reduced the availability of prey and refuge as well as disrupted migration for this life history type.

Yearling Chinook – During even-numbered years, juvenile Chinook salmon of this life history type may be entering marine waters at a time of reduced prey availability due to competition with pink salmon for resources (Ruggerone and Goetz, 2004). Any reduction in capacity as a result of non-support of the three smaller life history types within this sub-basin will potentially negatively affect yearling migrants. It is expected that parr migrating northward from Padilla/ Samish bays and other sub-basins to the south may be a significant source of food for yearling migrants. Yearlings will also require access to forage fish resources within the sub-basin. Any smaller life history types affected by an oil spill from the industrial center of Cherry Point or Bellingham Bay may also affect this life history type through lower prey availability or threat of toxic contamination of the food chain. Loss and degradation of small estuaries and shallow water areas has reduced the availability of prey and refuge as well as disrupted migration for this life history type.

Sub-adult and adult Chinook – We hypothesize that the survival of sub-adults and adults may be impacted by a decrease in abundance of Cherry Point herring. Water diversions and resulting high temperatures in the delta may affect migration and subsequent spawning success.

Listed summer chum – We hypothesize that Hood Canal/Eastern Strait of Juan de Fuca summer chum do not use this sub-basin.

Anadromous bull trout – Sub-adult and larger adult anadromous bull trout forage and migrate through nearshore and estuarine areas in and around Bellingham Bay (including Whatcom Creek, and historically Squalicum Creek), and may exploit areas further north and south of the Nooksack estuary (USFWS 2004). Prey availability, condition of prey (contamination), as well as availability, and access to productive regions are likely critical to sustaining this life history type in this sub-basin.

Table 6-2. Recommended Protection Actions for the South Georgia Strait

Protection Action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Aggressively protect areas, especially shallow water/low gradient habitats and pocket estuaries, within 5 miles of Nooksack River	Early marine support of all 4 life history types of Nooksack Chinook populations (feeding and growth, refuge, osmoregulatory, migration functions). Addresses all four VSP parameters	Support for neighboring Puget Sound populations (e.g., Skagit Chinook, larger juveniles, Fraser River populations). Functions addressed: feeding and growth, refuge, osmoregulatory, migration	
Protect small creeks, and larger creeks such as Dakota Creek.	Provides habitat diversity across the landscape and spatial structure to the Nooksack population.	Provides direct rearing utilization by juveniles from adjacent sub-basins	
Protect shorelines and marine regions used for spawning by Cherry Point herring stock.	Provides prey for larger juveniles (feeding and growth); and sub-adults	Provides prey for larger juveniles (feeding and growth); and sub-adults	Provides forage base for anadromous bull trout
Protect against catastrophic events (e.g., oil spills)	Allows for the possibility of all four juvenile functions to be realized; foraging areas, connectivity, and migration pathways for sub-adults and adults	Allows for the possibility of one or more juvenile functions to be realized; foraging areas, connectivity, and migration pathways for sub-adults and adults	Bull trout: connectivity of habitats, marine/estuarine foraging areas, prey resources
Protect from further armoring and overwater structures of any shoreline property located within green boxes 1,2,3 and 5 on the map in Figure E-1.5, Appendix E. These are important feeder sources for long, functioning drift cells within the South Georgia Strait sub-basin.	(see benefits to other Chinook)	Functioning littoral drift and sediment regime for beach maintenance and spit formation – pocket estuary and lagoon formation; forage fish spawning locations. Can address up to all four juvenile functions	Provides marine and estuarine foraging areas and prey resources
Protect functioning drift cells that support eelgrass bands and depositional features along Birch Bay and Drayton Harbor shorelines as well as Portage and Lummi Island shorelines.	Provides for feeding and growth, refuge and migration for older life history types – parr migrants and yearlings (and sub-adults?)	Provides for feeding and growth, refuge and migration for older and larger juveniles (and sub-adults)	May provide foraging locations for bull trout
Protect upland sediment sources in the rust-colored boxes 4 and 7 on the map in Figure E-1.5, Appendix E by assuring that water resources planning allows for seasonal overbank flooding which delivers sediment and wood debris to these deltas.	Provides for feeding and growth and refuge for older and larger life history types; sub-adults	Provides for feeding and growth, refuge and potentially osmoregulatory functions for juveniles; sub-adults	Provides for foraging locations and prey resources for bull trout
Removal of tide gates where beneficial and possible.	Increased area for which juveniles may exploit – up to all four functions may be satisfied.	Increased area for which juveniles may exploit – up to all four functions may be satisfied.	

Table 6-3. Recommended Improvement Actions for the South Georgia Strait

Improvement Action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Let natural processes control and accomplish reconnection of Nooksack/Lummi. Goal: create substantially more estuarine habitats. Re-creation of the Lummi River delta represents a riverine estuary restoration potential of regional significance. Could recover an increment of the 70 percent historic loss of this habitat type in a block large enough to restore ecologic processes at the regional scale. Few opportunities to restore a fully functional riverine delta exist.	Increased landscape connectivity via more estuarine habitats will benefit delta fry, especially, but also fry migrants and parr migrants (feeding and growth, refuge, osmoregulation, migration functions).	Increased landscape connectivity via more estuarine habitats will benefit larger juveniles (feeding and growth, refuge, migration functions)	Bull trout could potentially benefit from the expansion of habitat area – increased foraging opportunities, prey base.
Aggressively restore areas, especially shallow water/low gradient habitats and pocket estuaries, w/in 5 miles of Nooksack River	Early marine support of all 4 life history types of Nooksack Chinook populations (feeding and growth, refuge, osmoregulatory, migration functions). Addresses all four VSP parameters	Support for neighboring Puget Sound populations (e.g., Skagit Chinook, larger juveniles, Fraser River populations). Functions addressed: feeding and growth, refuge, osmoregulatory, migration	
Restore small creeks (and some larger creeks such as Dakota Creek)		Provides direct rearing utilization by juveniles from adjacent sub-basins	
Implement local actions that will contribute to the recovery of the Cherry Point herring spawning populations	Provides feeding and growth benefit to larger juveniles (potentially) and sub-adult and adults.	Support for neighboring Puget Sound populations (e.g., Skagit Chinook, larger juveniles, Fraser River populations) and sub-adults and adults. Functions addressed: feeding and growth	Provide for increased forage base and foraging area for bull trout.
Cap toxic sediments in Bellingham Bay; control amount of sediment reaching Bellingham Bay; address contamination concerns along industrial shoreline regions (e.g., Cherry Point).	Prevents contamination of the food web for all four life history types; sub-adults and adults. Decommission roads in watershed will limit sediment input which will benefit spawning adults	Prevents contamination of the food web for neighboring populations; sub-adults and adults	Prevents contamination of the food web for anadromous bull trout